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## METHOD FOR DEFLECTING FAST PROJECTILES

### Background of the Invention

1. Field of the Invention. The present invention relates to ordnance and more particularly to methods and apparatus for providing shielding from fast moving projectiles.

2. Brief Description of Prior Developments. The prior art discloses various methods and apparatus for shielding or protecting potential targets, surface vehicles, aircraft, gun emplacements, ships, troop concentrations and the like from projectiles.

U.S. Patent No. 5,635,260 to Rudolf, et al. discloses an arrangement for protecting an armored vehicle from projectiles. Upon triggering of a module by a sensor which calculates the attack trajectory of the projectile, two plates which are oriented in mutually parallel relationship are flung apart by electromagnetic or preferably pyrotechnic means. The two plates are oriented approximately parallel to the attack trajectory, and one of the two plates is acullerated parallel to the attack trajectory and hits the approaching projectile thereby altering the angle of the indecence to reduce kinetic energy or trigger the warhead. Even if the projectile impacts against the vehicle, penetration of the vehicle armor may be avoided.

U.S. Patent No. 5,824,941 to Knapper discloses another arrangement for protection from attack by projectiles. This arrangement consists of a wall which is constituted of explosives and is arranged obliquely relative to the firing direction below a wall facing towards the projectile. A foil consisting of an explosive for the formation of a or composite armor is equipped with a steel plate on one side thereof and with a glass plate or a glass fiber-reinforced plastic material plate on its other side. The composite armor forms chambers within a box structure such that, within any one chamber, a steel plate is always located opposite a glass plate. Collective foils of explosive are connected along their bottom sides with a transmission or transfer foil which is similarly constituted from an explosive.

U.S. Patent No. 6,029,558 to Stevens et al. discloses a counter-terrorism, reactive personnel protection system which detects the presence of a conclusive shock wave or ballistic projectile as it approaches a designed personnel target. Before impact, an air bag is rapidly inflated and interposed between the destructive force and the target so as to provide a protective barrier. The air bag is constructed from ultra-high molecular weight polyethylene material, and serves to halt or redirect the detected destructive force and thereby protect the designated target from attack.

U.S. Patent No. 6,244,156 to Stuer, et al discloses a blast shell which is launched as a defense against an attacking tail fin-stabilized projectile, such as, in particular, a KE penetrator, from an object which is to be protected. Gas fumes and a reaction pressure blast wave from a fired blast warhead of the shell act principally on the tail region of the attacking projectile. The penetrator is thereby deflected from a trajectory in the attack direction. so that the object under attack is either missed or at least is not hit in a head-on direction. The effectiveness

of the attacking projectile is thereby reduced.

A need still exists, however, for a still more efficient means for protecting potential targets such as vehicles, aircraft, gun emplacements, ships and troop concentrations and the like from high speed projectiles.

### Summary of the Invention

High speed projectiles have a plasma sheath associated with them in flight. Laser radiation of a wavelength not absorbed by the atmosphere can couple to the plasma and be absorbed. The absorbed energy increases the temperature and therefore the pressure on one side of the projectile, thus providing a deflection force. The required transverse momentum is some fraction of the projectile momentum. Larger projectiles which have greater momentum have larger transverse areas so the applied force (FEAPA) increases with area for the same pressure increase. Furthermore, larger projectiles are fired from longer ranges which provides greater lever arms for deflation, therefore requiring smaller angles of deflation. In addition assymetric drag force, which in turn may deflect the projectile

The present invention comprises a method for deflecting a projectile from an initial trajectory which takes advantage of this plasma sheaf. Such a projectile has a first surface area and a second surface area and moves through a gaseous atmosphere with a surrounding plasma sheath. This method includes the step of directing electromagnetic radiation toward the projectile, wherein the electromagnetic radiation has a frequency which is absorbed by the plasma sheath but is not substantially absorbed by the gaseous atmosphere. Ordinarily the

electromagnetic radiation will be directed toward the first surface area of the projectile in preference to the second surface area of the projectile. The first surface area and the second surface area are in opposed relation to each other. For example, the first surface area may be an upper surface area and the second surface area may be lower surface. Alternatively, the first surface area may be a front area and the second surface area may be a side area. The electromagnetic radiation is preferably light from a laser. The electromagnetic radiation causes the plasma sheath to be heated. The plasma sheath may be considered to have a first section adjacent the first surface area of the projectile and a second section adjacent the second surface area of the projectile. A temperature differential between the first section of the plasma sheaf and the second plasma sheaf results from directing the electromagnetic radiation toward the first surface area in preference to the second surface area. This temperature differential results in a pressure differential between said first surface area and said second surface area. Accordingly a traverse momentum is applied to the projectile resulting in a transverse impulse. The transverse impulse results in a deflecting force. The projectile may be a self-propelled rocket, an externally propelled shell, or an air delivered bomb. A fast moving projectile, as that term is used herein, will mean that the projectile will ordinarily have a velocity of from about 300 m/sec. to about 1500 m/sec.

#### Brief Description of the Drawings

The present invention is further described with reference to the accompanying drawings wherein:

Figure 1 is a side elevational view of a target aircraft and a projectile illustrating a

first step in the method of the present invention;

Figure 2 is a side elevational view of the target aircraft and the projectile illustrating a second step in the method of the present invention.

#### Detailed Description of the Preferred Embodiment

Referring to Figure 1, there is shown a target aircraft 10 and a projectile 12 which in this case is an air to air missile. The projectile 12 has an exhaust plume 14 which is indicative of a horizontal trajectory which puts it on an initial path directly toward the aircraft 10. The projectile 12 has a plasma sheath 16. A laser beam 18 is directed from the aircraft 10 toward the projectile 12 and the plasma sheath 16. The projectile 12 has a lower side 20 and an upper side 22 and front end 24 and a rear end 26. The laser beam 18 is made up of electromagnetic radiation which preferably has a wavelength of between 0.35 microns and 0.70 microns. In any case, the frequency should be selected so that the electromagnetic radiation is absorbed to a significant degree by the sheath 16 but not absorbed to a significant degree by the surrounding atmosphere 27. The laser beam 18 is directed to one side 20 of the projectile 12 relative to the other side 22 of the projectile 12 and its surrounding air and plasma sheath will tend to be heated more than its opposed side 22 and surrounding air and plasma sheath. In the case shown, the side 20 and its surrounding air and plasma sheath will tend to be heated to a higher temperature relative to the other side 22 and its surrounding air and plasma sheath and the surrounding atmosphere 27. Air pressure on the side 20 of the projectile 12 relative to the air pressure at the other side 22 of the projectile 12 will therefore tend to be higher with the result that the projectile 12, will tend to yaw or be deflected upwardly.

Referring to Figure 2, the method of the present invention continues with the

target aircraft maintaining an obliquely directed laser beam 28 on the projectile 12. It will be noted that the exhaust plume 30 and the trajectory of the projectile extend obliquely upwardly relative to the positions shown in Figure 1. At this point the laser would ordinarily be deactivated so that the projectile 12 would generally follow this upwardly oblique trajectory and thereby miss the target aircraft 10.

### Example

It is desired to deflect a projectile away from a target. The projectile has a speed of 1,000 m/sec. The projectile is at a range of about 3km from the target, and has a mass of about 0.5 kg. The projectile is cylindrical in shape and has a length of 63.5 mm and a diameter of 23 mm. It is desired to deflect the projectile by about 6m. The following relationships are pertinent to this situation.

$$\text{Impulse} = \text{FORCE} \times \text{TIME}$$

$$\text{FORCE} = \text{PRESSURE} \times \text{AREA}$$

$$\text{PRESSURE} = C \times \text{TEMPERATURE (where C is ideal gas constant/volume)}$$

$$\text{Temp} = C_v \times Q \text{ (where } C_v \text{ is specific heat)}$$

$$C_v \text{ varies with particular Absorber (e.g. gas, plasma)}$$

$$PV = NKT$$

Under the above circumstances, one of ordinary skill in the art will appreciate that a laser beam might be directed toward the projectile in the way described above to apply 212 J packets of energy over 0.1 sec. to deflect the projectile in the desired way.

It will be appreciated that a method has been described which will allow for an efficient and cost effective means for shielding or protecting a target from a high speed projectile.

Such targets may include, but not be limited to, surface vehicles, aircraft, gun emplacements, ships and troop concentrations.

While the present invention has been described in connection with the preferred embodiments of the various figures, it is to be understood that other similar embodiments may be used or modifications and additions may be made to the described embodiment for performing the same function of the present invention without deviating therefrom. Therefore, the present invention should not be limited to any single embodiment, but rather construed in breadth and scope in accordance with the recitation of the appended claims.